VOLTAGE REFERENCE GENERATOR

PRIORITY CLAIM

[1] This application claims priority from European patent application No. 02255482.8, filed August 6, 2002, which is incorporated herein by reference.

TECHNICAL FIELD

[2] The present invention relates generally to a voltage reference generator.

BACKGROUND

[3] When designing circuits for generating voltage references using modern high speed processes, it is often the case that the optimal or natural value for the reference voltage (***Vref***) is lower than the optimal value of the reference voltage in designs using older processes. In particular, the value of the voltage generated in the design of an industry standard 431 type reference generator is based around the base emitter voltage ***Vbe*** of a bipolar transistor. In circuits manufactured using more up to date process technology, this ***Vbe*** is generally lower than older process technology, so that the same circuit design generates a lower reference voltage.

[4] This poses a problem when there is a requirement to produce a reference voltage which is compatible with older designs/products: the new process technology would typically produce a reference voltage that was a little too low for the older design. Similarly, a difficulty arises when an older product needs to be transferred to newer process technology.

[5] The "correction" required is often only in the region of a few tens of ***mV***, but should preferably be nearly constant with temperature so as not to degrade the performance of the circuit using the reference voltage, or the reference itself as this is ideally constant in temperature.

[6] A known design to produce a variable voltage reference is shown in the circuit of **FIG. 1**. The circuit comprises a bipolar transistor ***TR1*** having its collector

connected to a supply voltage rail ***VDD***, its base connected to an input node ***4*** and its emitter connected via a resistor chain to the lower supply rail ***GND***. The resistor chain comprises three resistors ***RA***, ***RB*** and ***RC***. A ***VPTAT*** (voltage proportional to absolute temperature) generator ***6*** is connected to supply a voltage that is proportional to absolute temperature across the middle resistor, ***RB***. That voltage may typically be 60 ***mV*** at room temperature. This voltage sets the current ***I*** through the resistive chain ***RA***, ***RB***, ***RC***. The values of the resistors ***RA***, ***RB*** and ***RC*** are selected so that the total voltage V_{tot} across the resistor chain is roughly equal to the base emitter voltage ***Vbe*** of the transistor ***TR1***, that is around 0.62 V. Since the base emitter voltage of the transistor ***TR1*** has a negative temperature coefficient and the voltage V_{tot} across the resistive chain has a positive temperature coefficient, the net effect is a reference voltage ***Vref***, taken at the input node ***4***, which is very stable with temperature.

[7] A circuit of the form illustrated in **FIG. 1** is used in many products such as an industry standard 431 type voltage reference generator, and has a voltage reference value ***Vref*** of 1.24 V. If that circuit were to be produced using modern process technology, the reference voltage could fall to 1.20 V. This is mainly because the base emitter voltage of the NPN transistor ***TR1*** is lower using modern process technology, for example around 0.6 V. Therefore the optimal selection of the resistor values ***RA***, ***RB***, ***RC*** to maintain temperature stability of the reference voltage sets V_{tot} at around 0.6 V.

SUMMARY

[8] According to one aspect of the present invention, there is provided a voltage reference generator circuit for generating a reference voltage of a predetermined value comprising: first circuitry adapted to generate a first voltage which is substantially independent of temperature and related to a component parameter susceptible to variations with process technology; second circuitry adapted to generate an offset voltage of a value such that the sum of the first voltage and the offset voltage is said predetermined value, and wherein the second circuitry

comprises components whose parameters are variably selectable without affecting the first voltage.

[9] In the described embodiment, the first circuitry comprises a bipolar transistor, the base emitter voltage of which is susceptible to variations with process technology. Therefore, the first voltage varies with process technology. The offset voltage can be set to provide the required reference voltage depending on the value of the first voltage according to the process technology which is being used.

[10] Another aspect of the invention provides a voltage reference generator circuit comprising: a first bipolar transistor connected in series with a resistive chain between upper and lower supply rails and having an input node at its base; a current generating circuit connected to supply a current to a node of said resistive chain, said resistive chain including a compensation resistor connected between said node and said lower supply rail; voltage generating means for generating a voltage proportional to absolute temperature across a current setting resistor of said resistive chain; wherein the resistive value of the compensation resistor is selectable independently of the values of other components in the resistive chain, whereby an offset voltage across said compensation resistor is independently settable.

BRIEF DESCRIPTION OF THE DRAWINGS

[11] For a better understanding of the present invention and to show how the same may be carried into effect, reference will now be made by way of example to the accompanying drawings, in which:

[12] **FIG. 1** is a schematic diagram of a known voltage reference generator; and

[13] **FIG. 2** is a schematic diagram of a voltage reference generator in accordance with one embodiment of the invention.

DETAILED DESCRIPTION

[14] The following discussion is presented to enable a person skilled in the art to make and use the invention. Various modifications to the embodiments will be readily apparent to those skilled in the art, and the generic principles herein may be applied to other embodiments and applications without departing from the spirit and scope of the present invention. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[15] In **FIG. 2**, like parts are denoted with like designators as in **FIG. 1**. In particular, the circuit of **FIG. 2** includes the bipolar transistor ***TR1*** connected to the resistive chain ***RA***, ***RB***, ***RC***. The ***VPTAT*** generator circuit ***6*** is not shown in **FIG. 2** but exists to generate the voltage proportional to absolute temperature in the same manner as explained with reference to **FIG. 1**.

[16] The resistive chain ***RA***, ***RB***, ***RC*** terminates in a node ***8*** which is connected to the lower supply rail ***GND*** via a first compensation resistor ***Rcomp1***. A second compensation resistor ***Rcomp2*** is connected between the node ***8***, the base and collector of a second bipolar transistor ***TR2*** and one side of a current source ***10***. The other side of the current source ***10*** is connected to the upper supply rail ***VDD***.

[17] The emitter of the second bipolar transistor ***TR2*** is connected to the lower supply rail ***GND***. The reference voltage ***Vref*** is taken between the input node ***4*** and the lower supply rail ***GND***. The idea underlying the circuit of **FIG. 2** is that the value of the resistors ***RA***, ***RB*** and ***RC*** are selected so that the voltage across them is roughly equal to the base emitter voltage ***Vbe*** of the transistor ***TR1***. This provides a voltage which is relatively stable with temperature but, it will be recalled, is therefore somewhat set by the base emitter voltage ***Vbe*** of the first transistor ***TR1***. When using modern process technology, this is lower than with older process technologies, and may be of the order of 0.6 V. To take account of this,

an offset voltage is generated across the first compensation resistor ***Rcomp1***. Thus, the reference voltage ***Vref*** is given as follows:

$$Vref = Vbe + V(RA + RB + RC) + V_{offset} \qquad \text{(Equation 1)}$$

[18] The offset voltage V_{offset} is generated as follows. The current source ***10*** biases the second bipolar transistor ***TR2***. This produces a current through the second compensation resistor ***Rcomp2*** which is proportional to the base emitter voltage Vbe_2 of the second bipolar transistor ***TR2***. The current through the first compensation transistor ***Rcomp1*** is the sum of the current through the second compensation resistor ***Rcomp2*** and the current I through the current setting resistor ***RB*** and thus through the resistive chain as a result of the voltage proportional to absolute temperature generated across the resistor ***RB***. By suitable selection of the values of the compensation resistors ***Rcomp1*** and ***Rcomp2***, the offset voltage V_{offset} can be set at the absolute value required to correct the overall reference voltage generated by the circuit. In addition, the offset voltage is independent of temperature because the slight decrease with temperature exhibited by the effect of the second transistor ***TR2*** on the current I_2 through ***Rcomp2*** is offset by the increase in I with temperature. The currents I and I_2 are roughly of the same magnitude in one embodiment of the present invention.

[19] The embodiment of the voltage generator described above with reference to **FIG. 2** may be incorporated into an integrated circuit such as a memory device, which may, in turn, be incorporated into an electronic system such as a computer system.

[20] From the foregoing it will be appreciated that, although specific embodiments of the invention have been described herein for purposes of illustration, various modifications may be made without deviating from the spirit and scope of the invention.